

## POLICY RESEARCH WORKING PAPER

# Short-Term Supply Response to a Devaluation

## A Model's Implications for Primary Commodity-Exporting Developing Countries

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The success of devaluation depends on the "right" timing of the primary export commodity's production cycle and on the absence of middlemen who affect the devaluation's pass-through to producers.



## Summary findings

Boccara and Nsengiyumva evaluate whether, in the short run, a devaluation could be contractionary in developing countries that export primary commodities. To do so, they use a model capturing the principal features of those economies.

The two most important channels for transmitting the change in parity are (1) a supply effect with the supply response for tradables essentially a function of labor costs relative to the export commodity price, and (2) a demand effect, with the supply response for the semi-tradables essentially a function of the real wage.

They simulate the model for a middle-income and a low-income country. The economic structure of the low-income country is less flexible (lower supply elasticity in production, lower elasticity of substitution between domestic production and imported inputs) than in the middle-income country.

The model is meant not for use as a forecasting tool but to show the relative magnitude of various effects that are relevant in countries where the initial supply response to a devaluation would come mostly from increased production of an export commodity. In particular, Boccara and Nsengiyumva analyze the difference between the producer's response under "wrong" timing (the predevaluation price is the price signal on which production decisions are based) and

under the presence of middlemen (rentiers in the export sector whose presence affects the devaluation's pass-through to producers).

Their findings:

- For devaluation to succeed, there must be little wage indexing. Devaluation is more likely to be expansionary in the middle-income than in the low-income country.

- The devaluation's timing with the production cycle of the primary commodity export matters, especially in the middle-income country.

- Debt relief is more effective where wage indexing is low and can help offset the negative effects of "wrong" timing by increasing output. But debt relief has an asymmetric effect on exportable and semitractable sectors, as the production of semitractables increases while that of exportables decreases.

- With a tariff reduction, the devaluation implies more expansion in tradables. But this is not enough to compensate for the relative decrease in the growth rate of production of nontradables, so the growth of total output declines.

- Unless the timing is "right," the effects of redistribution (with income being "transferred" from producers to middlemen with a higher propensity to consume imported goods) can have contractionary effects that cannot be offset by debt relief.

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This paper — a product of the Country Operations Division, Western Africa Department — is part of a larger effort in the region to prepare for devaluation of the CFA franc. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Mather Pfeiffenberger, room J9-261, extension 34963 (26 pages). February 1995.

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**A MODEL'S IMPLICATIONS FOR PRIMARY COMMODITY-EXPORTING**  
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**1 Introduction**

While it is widely accepted that in the long run, a depreciation of the real exchange rate will improve the current account and stimulate economic activity, there is a growing consensus that devaluations can have, in the short-run, contractionary effects on output. The purpose of this paper is to evaluate the circumstances under which, in the short term, a devaluation in primary commodities exporter less developed countries could have contractionary effects.

To do so, a model capturing the principal features of these economies has been used to evaluate the short-run impact of a devaluation. The model itself is not meant to be used as a forecasting tool but rather to illustrate and show the relative magnitude of various effects which are relevant in countries where the initial supply response to a devaluation would mostly come from an increased production of an export commodity. In particular, the paper analyzes the difference between the producer's response under a "wrong" timing (in the sense that the pre-devaluation price is the price signal on which production decisions are based) and under the presence of middlemen (rentiers in the export sector whose presence affects the devaluation's passthrough to producers).

The model is simulated for two economies, that of a "middle-income" country and that of a "low-income" country. The economic structure of the "low-income" country is less flexible (lower supply elasticity in production, lower elasticity of substitution between domestic production and imported inputs) than that of the "middle-income" country.

Section 2 discusses the channels identified in the literature through which a devaluation could be

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<sup>1/</sup> The views expressed in this paper do not necessarily reflect the views of the World Bank and its affiliates. Any errors in this paper are the sole responsibility of the authors.

contractionary. Section 3 develops a simple model to evaluate the impact of a devaluation on aggregate output. Section 4 analyzes the results of model simulations and discusses policy implications. Section 5 concludes the paper.

## **2 Channels through which a Devaluation can be Contractionary**

### **2.1. Introduction**

To focus on the effects of a devaluation, Edwards (1989) uses pooled data from 12 developing countries to regress real GDP on a country specific time trend, a money variable (with lags), the terms of trade (with lags), a fiscal variable (with lags), and the nominal exchange rate (with lags). Edwards' findings of significant negative coefficients for the nominal exchange rate variable (without lag) support the growing literature -reviewed below- which emphasizes that devaluations can have, in the short-run, contractionary effects on output.

Krugman and Taylor (1978) showed that contrary to the view that substitution effects associated with a real depreciation are sufficiently strong to assure an expansionary effect on output and employment, there were several channels through which a devaluation could be contractionary. They show that income effects transferring real purchasing power toward economic actors with higher propensity to save can create excess savings and reductions in real output under the following circumstances:

- i) With an existing trade deficit, price increases of traded goods reduce real income at home;
- ii) Even if foreign trade is in balance, a devaluation implies profits in export and import-competing industries. If there is a decrease in real wages and if the marginal propensity to save is higher from profits than from wages, there can be a contraction; and
- iii) If trade taxes are an important source of government revenues, a devaluation, by redistributing income from the private sector to the government, can reduce aggregate demand if the marginal propensity to save from the government is higher than that of the private sector.

On the other hand, Hanson (1983) argues, using a more general model in which substitution in consumption and production is allowed, that it is not very likely that a devaluation will reduce aggregate demand.

Thus, the absence of a general relationship between aggregate output and devaluation comes from the fact that the answer depends upon whether the various channels through which a devaluation can exert a contractionary effect are relevant

in a certain country and at a certain time and we now turn to a discussion of the relevance to primary commodity exporter LDC's of the various channels of transmissions mentioned above. What follows is based on earlier work by Lizondo and Montiel (1988).

## **2.2. Effects on Aggregate Demand**

Under the assumption that a country is a price taker, the total demand for the primary commodity export produced by the country can be assumed to be unaffected by the devaluation since in most cases the domestic component of that demand can be assumed to be negligible. On the other hand, the relative demand for semitradable and nontradable goods depends on their relative domestic price, and on the elasticity of substitution in consumption. (See, for example, the models by Devarajan et al. (1987, 1993).

A devaluation also affects the demand for domestically-produced goods since it produces changes in real income. Lizondo and Montiel (1988) show that the direction of change in real income at the initial level of output depends on whether traded goods have a higher share in consumption or in income. The presence of imported inputs make it more likely that the real income effect will be negative but this may not necessarily be so if domestic producers substitute labor for imported inputs (assuming that the real wage did go down). The net effect will depend on the elasticity of substitution in production.

As has been mentioned, a devaluation can also generate a redistribution of income from groups with low marginal propensity to save to groups with high marginal propensity to save, resulting in decline in aggregate demand. However, in his survey of 39 devaluation episodes, Edwards (1989) finds very little evidence of significant changes in income distribution in the period surrounding the devaluations.

Another channel through which devaluation can affect aggregate demand is through the stock of net foreign assets. The overall effect on demand depends upon the composition of the stock and debt financing 2/.

Finally, the net effect of a devaluation on investment is quite complex and, in theory, indeterminate since the various

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2/ An increase in the domestic currency value of foreign assets would be expansionary if foreign assets are repatriated (reverse capital flight). The effect of the public sector external debt will be contractionary (unless the devaluation is accompanied by compensatory debt relief) only if the increased debt service payments are financed by reduced spending (unless it concerns imports only) or increased taxation.

channels which influence investment behavior may work in opposite direction. (See, for example, Chhibber and Shafik, 1992.) Furthermore, as argued in Dornbusch (1990), investors are likely to adopt a wait and see attitude and there is a possibility that an economy get trapped in an inferior equilibrium where the transition from stabilization to growth does not materialize.

### **2.3. Effects on Aggregate Supply**

In addition to the demand related effects identified above, there are a number of supply-side channels which influence the impact of a devaluation on aggregate output.

The increase in the price of intermediate inputs is the most important channel through which a devaluation can be contractionary. As a devaluation makes these inputs more expensive, in domestic currency, the marginal cost of producing nontradable increases. (See, Taylor, 1983.)

Labor is an essential cost of production and the effects of a devaluation on aggregate supply are largely a function of what happens to real wages in each sector.

Finally, the structuralist school (see, for example, van Wijnbergen, 1983) has also emphasized that a devaluation can be contractionary if financing costs for labor and imported inputs (which arise because suppliers often need to borrow to pay for factor inputs -labor and intermediate goods- until they get paid for their products) rise as a result of an increase in nominal interest rates.

We now turn to a simple model to illustrate, in the case of a typical primary commodities exporter less developed country, the effects identified above. Although the model developed below is fairly general in its applicability, the research was motivated by the January 1994 devaluation of the CFA franc and the economic structure underlying the construction of the model corresponds to that of a typical CFA country.

## **3 Devaluation and Aggregate Output Model**

### **3.1 Structure of the model**

The model developed in this section is similar in spirit to that of Devarajan and de Melo (1987), and Edwards (1989).

Consider a small open economy characterized by three sectors:

- a primary commodity export sector (cash crops such as cotton, coffee, and groundnut) with an exogenous international dollar price;
- a small manufactured goods sector where goods and services domestically produced compete with imported goods; and
- a nontradable goods sector.

In what follows, a two-sector model is constructed as the manufactured and the nontradable goods sectors are aggregated into a semitradable good sector with limited substitution possibilities with imported goods. The consumption basket of residents includes semitradables (whose production requires imported intermediate inputs) and imported goods. There is no domestic consumption of the primary commodity export. The world prices of the primary commodity export and of semitradables are assumed fixed since we are not analyzing changes in terms of trade.

To reflect the short-run nature of the model, the capital stock is assumed to be sector specific and fixed and investment responses are ignored <sup>3/</sup>. The model also abstracts from interest rate effects on the cost of working capital since we assume perfect capital mobility which would prevent the domestic nominal interest rate to be greatly affected by a devaluation. (We ignore agents' expectations of future devaluations.)

Thus, the model incorporates three important channels through which a devaluation can be contractionary: (1) intermediate imported inputs; (2) presence of foreign debt; and (3) behavior of nominal wages. The model is used to discuss the timing of a devaluation with respect to the production cycle of the primary commodity export. An extension of the model incorporating income redistribution effects is used to discuss the presence of middlemen (rentiers in the export sector whose presence affects the devaluation's passthrough to producers.

### 3.2 Equations of the model

Let  $X$ ,  $Q$ , and  $M$  designate the quantities of exportables, semitradables, and imports for final consumption (i.e., excluding intermediate inputs).

The model assumes the following production functions:

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<sup>3/</sup> In practice, investment can have a short-term effect (e.g., construction boom) but, for ease of exposition, this is ignored in the model.



• two-stage Constant Elasticity of Substitution for the production of semitradables with an elasticity of substitution  $\sigma = (1+\rho)^{-1}$  between value added  $V$  and imported intermediate inputs  $I$  <sup>4/</sup> ; and

• Cobb-Douglas for the production function of exportables and value added in the semitradable sector.

Thus, we have:

$$Q = k[\beta I^{-\rho} + (1-\beta) V^{-\rho}]^{-\frac{1}{\rho}} \quad (1)$$

$$V = \bar{A}_Q L_Q^\gamma \quad (2)$$

$$X = \bar{A}_X L_X^\theta \quad (3)$$

where  $L_X$  and  $L_Q$  designate labor in the exportable and semitradable sectors.

Let  $P_X^*$  designate the international price of exports,  $P_I^*$  the international price of imports and of intermediate inputs, and  $e$  the nominal exchange rate (in domestic currency per unit of foreign currency). Let  $P_M$  designate the domestic price of all imports,  $P_V$  the price of value added, and  $P_Q$  the price of domestic good. Given profit maximization and perfect competition, we have:

$$P_V V + P_M I = P_Q Q \quad (4)$$

with

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<sup>4/</sup> An alternative assumption about the production of semi-tradable is

$$Q = \text{Min} \left( \frac{1}{a} V, \frac{1}{b} I \right)$$

in which case (production will be at a "corner solution" unless one of the factor has a zero opportunity cost), we have

$$V = aQ, \quad I = bQ$$

This is simpler but does not leave any possibility for substitution between domestic factors and imported intermediate inputs.

$$P_M = eP_M^*(1+t)$$

where  $t$  designates the average ad-valorem import tariff.

The first-order condition associated with the production function of equation (1) is 5/

$$\frac{I}{V} = k' \left( \frac{P_V}{P_M} \right)^{\theta} \quad (5)$$

where  $k'$  is a constant.

In the presence of an export tax  $s$ , the price signal received by the producer (i.e. the price on which the production decision is based) is  $(1-s)eP^*$  and the government receives  $s e P^* X$  in tax revenues since the F.O.B. price is  $e P^*$ .

We now introduce a variable  $\psi$  related to the timing of the devaluation with respect to the production cycle of the export commodity. Let  $\psi e_{\text{[ex-post devaluation]}}$  designate the effective nominal exchange rate, the one that matters to producers for their production decision. If at the time the devaluation occurs, all production decisions have already been made (e.g., devaluation having been announced and taken place after planting of an agricultural commodity), then the effective nominal exchange rate is equal to  $e_{\text{[ex-ante devaluation]}}$  (as long as production decisions are irreversible). In this case the price signal that matters to the producers is the one that prevailed before the devaluation. In the opposite case, that of a perfect and timely passthrough, we would have  $\psi e_{\text{[ex-post devaluation]}}$  equal to  $e_{\text{[ex-post devaluation]}}$ .

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5/ Equation (5) can be derived from

$$\frac{\partial Q}{\partial I} = \beta k^{-\beta} Q^{1+\beta} I^{-(\beta+1)} ; \quad \frac{\partial Q}{\partial V} = (1-\beta) k^{-\beta} Q^{1+\beta} V^{-(\beta+1)}$$

and

$$P_Q \frac{\partial Q}{\partial V} = P_V ; \quad P_Q \frac{\partial Q}{\partial I} = P_M$$

To be able to analyze all intermediate cases, we consider  $\psi$  a continuous variable ( $0 < \psi < 1$ ) such that 6/

$$\Phi = \tau \hat{\epsilon}$$

with,

$$\tau \in [-1, 0].$$

If  $\tau = -1$ , the timing of the devaluation is labelled "wrong" in the sense that it occurs too late since all production decisions (based on a less favorable exchange rate) have already been taken. Conversely, if  $\tau = 0$ , the timing of the devaluation is labelled "right" and the supply response will be the maximum attainable, given the technological constraint defined by the production function.

Note that although the behavior of the producers is conditioned by the price which they perceived, the price actually paid is  $(1-s)e P_x^*$  and not  $(1-s) \psi e P_x^*$ . In other words, no "monies" disappear and all accounting identities are respected. Since the F.O.B. price in domestic currency instantly adjusts to the new parity, the producers receive the new F.O.B. price (minus export taxes) but they do so on a quantity which is determined by the effective as opposed to the actual nominal exchange rate.

Thus, to capture the influence of the effective nominal exchange rate on the production decision, we write the first-order conditions associated with equations (2) and (3) as:

$$W = P_V \bar{A}_D \gamma L_D^{\gamma-1} \quad (6)$$

and

$$W = (1-s) \psi e P_X^* \bar{A}_X \theta L_X^{\theta-1} \quad (7)$$

Nominal wages are adjusted by a proportion  $\omega$  of the price on semitradable goods:

$$\hat{W} = \omega \hat{P}_D \quad (8)$$

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6/ As usual, a ^ on top of a variable indicates percentage changes.

where  $W$  is the wage level.  $w$  can be considered a proxy for capacity utilization since the degree of wage indexation can be assumed to be an increasing function of capacity utilization since there will be additional pressure on wages if the economy is experiencing capacity bottlenecks. On the other hand, the presence of unutilized capacity is likely to limit the extent to which wage would be adjusted, reduce inflationary pressure and increase the probability that the devaluation would not be contractionary 7/.

On the demand side, we assume that a fixed proportion  $m$  of government spending  $G$  is spent on imports. Let  $C$  designate private demand for semitradables. In equilibrium, the market for semitradables clears and we have:

$$(9) \quad Q = C + G(1-m)$$

The output of semitradable goods  $C$  is an imperfect substitute for imports  $M$ , in private consumption. Assuming that private sector preferences are described by a constant elasticity of substitution utility function, the relative demand of semitradables and imports is a function of the relative consumption prices and we have:

$$\frac{C}{M} = \bar{K} \left[ \frac{P_M^* (1+t) e}{P_D} \right]^\Omega \quad (10)$$

where  $\Omega$  is the elasticity of substitution of semitradables for imports.

Equation (10) can be derived from the first-order condition:

$$\frac{U_C}{U_M} = \frac{P_D}{eP_M^*(1+t)}$$

with the C.E.S. utility function:

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7/ Alternative assumptions about the labor market include: i) full employment; ii) fixed real wage when expressed relative to the price of imported goods or the price of semi-tradable goods; and iii) wage indexation with respect to the general price level.

$$U = h[\delta C^{-\epsilon} + (1-\delta)M^{-\epsilon}]^{-\frac{1}{\epsilon}}$$

with  $\Omega = (1+\epsilon)^{-1}$ .

The private sector income is equal to the sum of wages and profits in both the semitradable and exportable sectors. The associated budget constraint is:

$$(1-s)eP_X^*X + P_VV = P_QC + eP_M^*(1+t)M \quad (11)$$

Note here that the variable  $\psi$  is absent from this equation. Again this is due to the fact that, in the end, although  $\psi$  will have influenced the producers' response, the price actually paid to them (even if they did not anticipate it at the time the production decision was made) will be the ex-post price which takes fully into account the devaluation.

External balance is given by:

$$P_X^*X + \bar{F} = P_M^*(M+I+mG) + \mu i^*D^* \quad (12)$$

where  $F$  is exogenous foreign capital flows;  $D^*$  is the external debt,  $i^*$  is the nominal interest rate on foreign debt payments; and  $\mu$  is a parameter of debt relief comprised between 0 and 1.

Given Walras' Law, the government's budget constraint is verified (it can be obtained from equations (4), (9), (11), and (12)) and is given by:

$$P_QG(1-m) + eP_M^*mG + e\mu i^*D^* = e(tP_M^*(M+I) + sP_X^*X) + e\bar{F}$$

$P_X^*$  is chosen as the numeraire and in the log-differentiation of the equations of the model,  $\hat{P}_X^*$  is systematically set to zero.

### 3.3. Approach to Evaluate Impact of Devaluation

The objective of the model is to allow us to evaluate, under various hypotheses, the impact of a devaluation on real output and inflation and analyze the sensitivity of the results to changes in policy and exogenous parameters.

The model has twelve equations and twelve unknown. The following variables are endogenous:

$X$ ;  $Q$ ;  $L_X$ ;  $L_Q$ ;  $I$ ;  $V$ ;  $P_Q$ ;  $P_Y$ ;  $W$ ;  $C$ ;  $M$ ; and  $G$ .

The exogenous variables are:

$P_M^*$ ;  $F$ ;  $i^*$  and  $D^*$ .

The policy and exogenous parameters are:

$e$  and  $\tau$  for the devaluation and its timing;

$\mu$  for debt relief;

$t$  and  $s$  for trade policy; and

$\omega$  for the degree of wage accommodation (as a proxy for capacity utilization).

Real output is given by:

$$Y = \frac{1}{P_Y} (P_Q Q + e P_X^* X)$$

with

$$P_Y = P_Q^v (e P_X^*)^{1-v}$$

where  $P_Y$  is the aggregate output deflator and  $v$  is the share of semitradables in output 8/.

The strategy used to solve the model is to first log-differentiate equations (1) through (12) having replaced  $P_M$  by its expression given in the text. Percentage changes in the endogenous variables can be expressed as a function of percentage changes in the exogenous variables and  $P_Y$  which, in turn, can be expressed as a function of percentage changes in the exogenous variables. The detailed calculations and the exact expressions for all the parameters are shown in the Appendix.

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8/ Note that the simulation results on the response of output to the devaluation under various assumptions (timing, debt relief, etc.) were not affected by the choice of the value of the parameter  $v$  in the sense that the relative magnitude and directions of effects were always similar. Thus, by simulating the model for several values of  $v$ , it was verified that the results presented in the section that follows are not simply capturing effects valid only for specific values of  $v$ .

The simulations are used to analyze the sensitivity of the results to wage indexation ( $\omega$ ), timing of devaluation ( $\tau$ ) with respect to the production cycle of the export commodity, and debt relief ( $\mu$ ). The model is also used to assess the impact of a devaluation in conjunction with a reduction in tariffs. Finally, a redistribution effect is introduced in an extension of the model to evaluate another channel through which a devaluation can have contractionary effects.

#### 4. Simulation Results

This section is divided into six parts: the first part discusses the values of the parameters used to calibrate the model. The next three parts discuss the influence of wage indexation on the supply response in the case of a "right" timing and compare this base case with simulations results for a "wrong" timing with and without debt relief. The fifth part introduces tariff reductions and the last part introduces a redistribution effect.

##### 4.1. Parameter Values

To simulate the impact of a devaluation, we need to set values for the 2 elasticities of substitution  $\sigma$ , and  $\Omega$  and for the following 13 shares:

- $\theta$  = share of labor in value-added in the export sector;
- $\gamma$  = share of labor in value-added in the semitradable sector;
- $m$  = share of government spending on imports;
- $\lambda_i$  = share of imported intermediate inputs in the production of semitradables;
- $\lambda_g$  = share of government consumption of semitradables;
- $\mu_i$  = share of imported intermediate inputs in output of semitradables;
- $\gamma_x$  = share of exports in foreign exchange receipts;
- $\gamma_m$  = share of private final imports in total foreign exchange expenditures;
- $\gamma_D$  = share of debt service payments in total foreign exchange expenditures;
- $\gamma_i$  = share of total intermediate imports in total foreign exchange expenditures;
- $\theta_g$  = share of semitradables in private sector expenditures;
- $\theta_x$  = share of revenue from export sector in private sector income; and
- $v$  = share of nominal value of semitradables in nominal value of total output.

The values of the first two shares  $\theta$  and  $\gamma$  implicitly determine the values of the (price) supply elasticity in the export sector (equal to  $\theta/(1-\theta)$ ) and of the (price) supply

elasticity of value added in the semitradable sector (equal to  $\gamma/(1-\gamma)$ ).

The thirteen shares for the "middle-income" country are based on 1991 values for Cote d'Ivoire. The economic structure of the "low-income" country is assumed to be relatively more constrained on the production side than the "middle-income" country in terms of imported inputs, local production capacities (infrastructure) and diversification of sectors of production. It could, for example, corresponds to the economic structure of some of the poorer landlocked Franc zone Sahelian countries in Africa. The three production-related elasticities, i.e., the supply elasticity in the export sector, the supply elasticity of value-added in the semitradable sector, and the elasticity of substitution between value added and imported intermediate inputs ( $\sigma$ ) are assumed to be higher in the "middle-income" country than in the "low-income" country. The values used for the short-term elasticity of export supply are respectively 0.11 for the "middle-income" country and 0.053 for the "low-income" country which corresponds to labor shares of value-added in the export sector  $\theta$  respectively equal to 0.1 and 0.05 9/. The values used for the supply elasticity in the semitradable sector are respectively 1.5 for the "middle-income" country and 1 for the "low-income" country which corresponds to labor shares of value-added in the semitradable sector  $\gamma$  respectively equal to 0.6 and 0.5 10/. The value of the elasticity of substitution between intermediate imported inputs and domestic value added ( $\sigma$ ) is assumed to be 0.2 in the middle-income country and 0.1 in the low-income country.11/

On the demand side, the substitution elasticity between semitradables and imported final goods ( $\Omega$ ) is assumed to be equal to 0.5 in both countries.12/ The level of this elasticity depends essentially on preferences, and the pattern of these preferences does not basically differ in the two typical countries.

On the supply side, it is expected that the share of imported inputs in the production of semitradables in real ( $\lambda_x$ ) and in nominal ( $\mu_x$ ) terms, the share of revenue from the export sector in private sector revenue ( $\theta_x$ ), and the share of exports in total foreign exchange receipts ( $\gamma_x$ ) will be higher

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9/ The choice of these parameters is consistent with the elasticities shown in Pritchett (1992).

10/ The estimated value for the labor share of value-added ( $\gamma$ ) is 0.57 in Branson (1986).

11/ Branson uses 0.2 for Kenya.

12/ 0.5 is also the value used by Devarajan (1987).



in the "middle-income" country than in the "low-income" country. On the other hand, the share of semitradables in total nominal output ( $v$ ) would be lower in the "middle-income" country than in the "low-income" country.

Generally the share of semitradables in private sector expenditures ( $\theta_s$ ), the share of private sector imports in foreign exchange expenditures ( $\gamma_m$ ), and the share of government consumption of semitradables ( $\lambda_s$ ) are higher in the "low-income" country than in the "middle-income" country. On the other hand, we expect to have lower values for  $m$  (share of government spending on imports) and  $\gamma_p$  (share of debt service payments in foreign exchange expenditures) in the "low-income" country. Finally, the share of total intermediate imports ( $\gamma_i$ ) in foreign exchange expenditures ( $\gamma_i$ ), the tariff rate ( $t$ ) and the export tax rate ( $s$ ) are assumed to be the same for the two typical countries.

The values chosen for  $\sigma$  and  $\Omega$  and the estimated values for the thirteen shares as well as the values of the tax rates (parameter  $t$  and  $s$ ) are given in Table 1 for both the "middle-income" and the "low-income" countries.

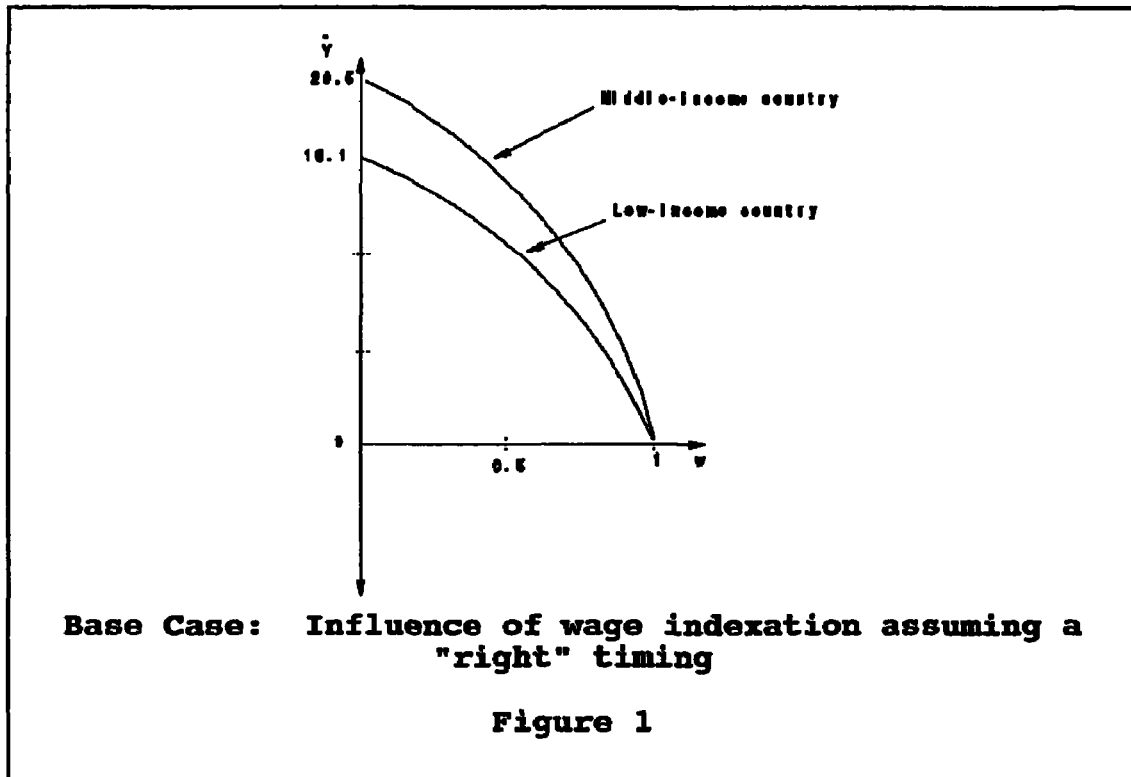
Since the methodology used to evaluate various effects consists of log-linearizing the model and working with the reduced linear form to study non marginal changes, the results that follow should not be used for forecasting growth in output following a devaluation since the absolute magnitude are not meaningful (they are simply a function of how the model is calibrated). On the other hand, the relative magnitude allow us to understand the strength of the various effects being analyzed and infer appropriate policy responses. The results are fairly robust in the sense that they are not very sensitive to the values selected for both elasticities of substitution.

#### **4.2. Short-term Impact of a Devaluation (Base Case): Influence of Wage Indexation**

The results shown in this sub-section represents our benchmark against which we compare all the other simulation results. Figure 1 shows the influence of wage indexation on the percentage change in total output following a 100% devaluation. The timing is assumed to be "right" (i.e.,  $\tau = 0$ ).

Since the observed supply response is a function of the real wage, the expected growth in output is less as the degree of wage indexation increases. In the extreme case of having the real wage, expressed in terms of the price of tradables, unchanged (full accommodation which cancels the effects of the devaluation), there is no change in output. The same is true for a full employment version of the model. Furthermore, the

more  $\omega$  increases, the more the relative loss in output growth (i.e., the curves in Figure 1 are convex). This relationship is stronger for the middle-income country, the corresponding curve being more convex.



The policy recommendation from these results is straightforward: the "middle-income" country would suffer relatively more losses in terms of maximum potential output than the "low-income" country and, therefore, has relatively more to gain on limiting wage indexation than the "low-income" country.

#### 4.3. Sensitivity of the Results to the Timing of the Devaluation.

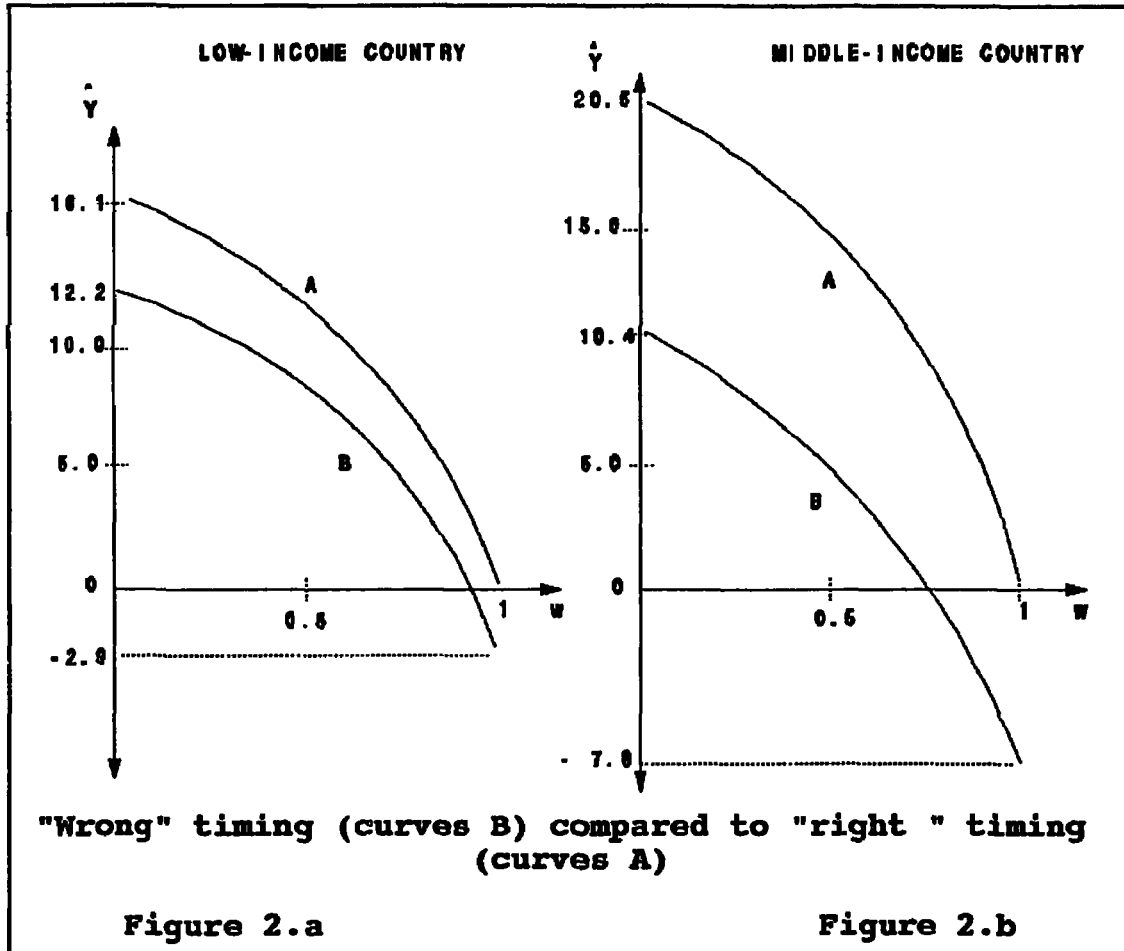
Figures 2-a and 2-b show for both types of countries how a "wrong" timing affects the outcome of the devaluation. In both cases, as expected, the curve for the "wrong" timing (curve labelled B) is below that for the "right" timing (curve labelled A which, for each type of country, is identical to the ones of Figure 1). How much below gives an indication of the cost associated with a poor timing of the devaluation.

The results show the following:

- i) The comparative loss in terms of sacrificed potential output growth from a "wrong" timing would be higher in the "middle-income" than in the "low-income" country, whatever the

degree of wage indexation be. This result is due to the fact that the supply elasticity and the share of the export sector in total output are assumed to be higher in the "middle-income" than in the "low-income" country.

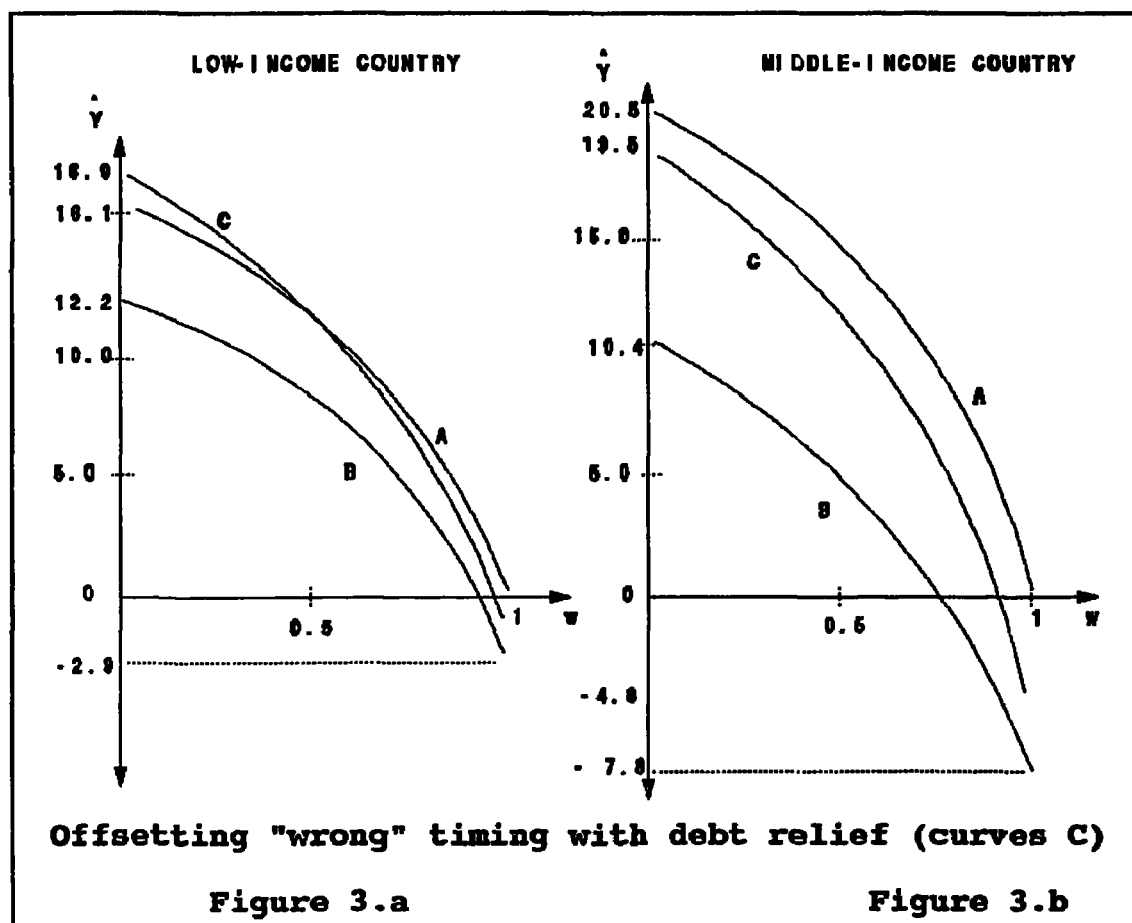
ii) In both cases, timing matters even more, in the sense that the comparative losses are greater under a "wrong" timing if there is a lower degree of wage indexation.



Note also that with a "wrong" timing, there are possibilities of a contractionary devaluation as the degree of wage indexation increases. This is especially true for the "middle-income" country. Thus, as has already been seen, a low degree of wage indexation is crucial to the supply effect of a devaluation.

#### 4.4. Effects of a Devaluation Accompanied with Debt Relief

In this sub-section, we investigate whether the effects of a "wrong" timing can be "corrected" by debt relief <sup>13/</sup>. Thus, Figures 3.a and 3.b show, for both type of countries, an additional curve (labelled curve C) which corresponds to a scenario of a devaluation with the "wrong" timing ( $\tau = -1$ ) and a full debt relief (i.e.,  $\beta = -1$ ).



The results show the following:

i) In both cases, debt relief helps by increasing the growth rate of total output thereby decreasing the contractionary effects. Note, however, that debt relief has

<sup>13/</sup> Assuming that a given devaluation takes place simultaneously in a "middle-income" and in a "low-income" country, a theoretical policy question is on which country's production cycle should the timing be based and (assuming that the production cycles differ drastically across the two countries) the extent to which debt relief can help offset the "wrong" timing.

an asymmetric effect on the exportable and the semitradable sectors: It allows an expansion of semitradables while decreasing the supply response of the exportables. The mechanism by which the export sector is hurt is similar to that of an inflow of foreign exchange with the accompanying well known phenomena of dutch disease. Debt relief positively affects government revenues and relaxes the foreign exchange constraint thus allowing for an increase in aggregate demand which is inflationary. In turn, the resulting increase in nominal wage reduces the profitability of the exportable sector and leads to a lower expansion of that sector. The increase in aggregate demand results in an expansion of the semitradable sector. The magnitude of this expansion mainly depends on the share of interest payments in foreign exchange expenditure ( $\gamma_p$ ).

ii) Debt relief is more powerful whenever the degree of wage indexation is lower: The relative gain in terms of being able to undo the effects of a "wrong" timing are greater for a lower degree of wage indexation. Furthermore, the relative gain is more important for the "middle-income" country although the effects of a "wrong" timing are more likely to be completely undone for the "low-income" country (since  $v$ , the share of semitradables in output, is likely to be higher for the "low-income" country).

Finally, we found that debt relief results in a worsening of the current account deficit (the rate of growth for imports increases and the rate of growth for exports decreases with a debt relief), reinforcing the need for additional debt relief or exogenous foreign capital inflows in the future. This worsening of the current account is less with a lower degree of wage accommodation.

#### 4.5. Devaluation and Tariff Reduction

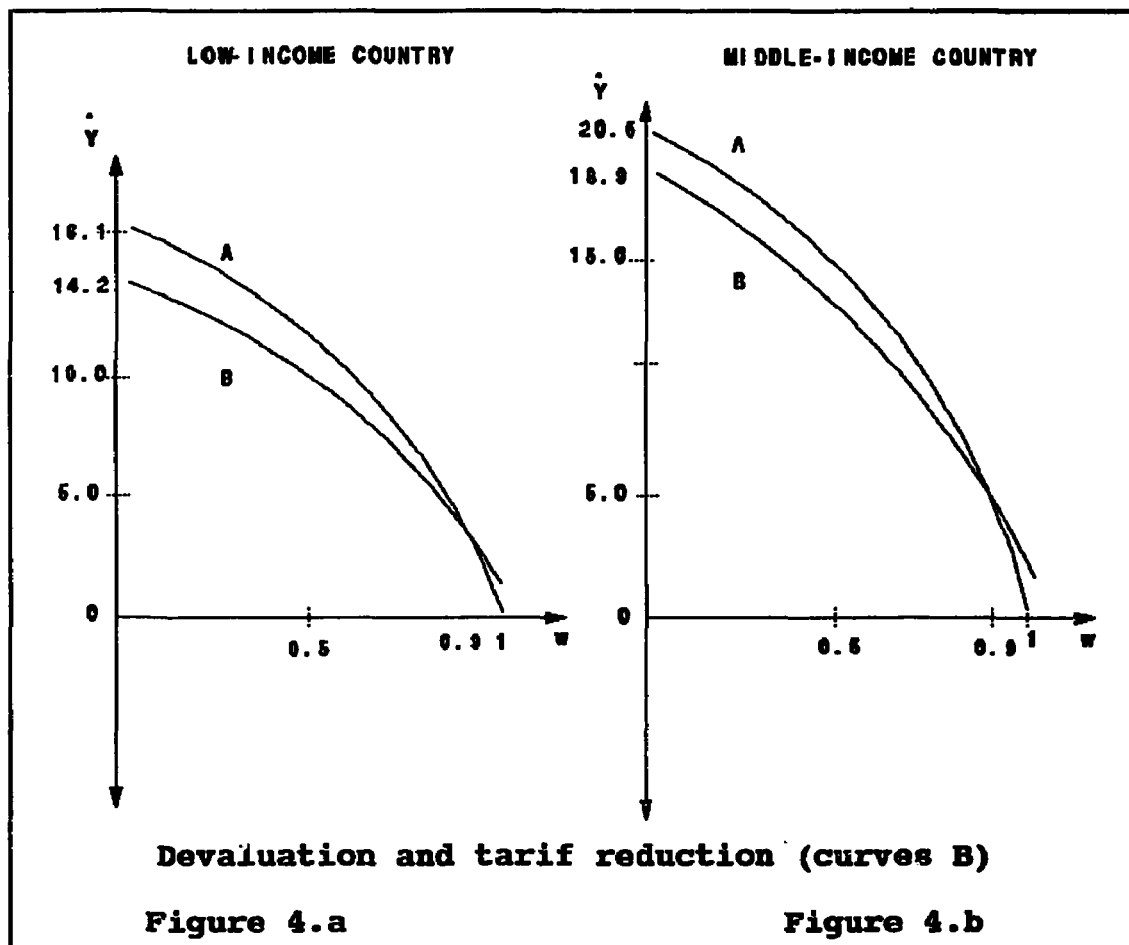
In this section, we simulate a 100 percent devaluation along with a 50 percent cut in tariff starting from an initial average tariff of 30 percent. (This roughly approximates what took place in some of the CFA countries after the January 1994 devaluation). Timing and debt relief issues are ignored (i.e.,  $\tau = 0$ ;  $\mu = 1$ ). The results are shown in Figures 4.a. and 4.b. for both countries. On each figure, we show both the curve for the base case (curve A as before) and the curve with the tariff reduction (labelled curve D) <sup>14/</sup>.

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<sup>14/</sup> Essentially, a 100 percent devaluation accompanied by a 50 percent tariff reduction starting from an average tariff of 30 percent can be thought of as a 88 percent nominal devaluation since

$$\hat{e} + \frac{t}{1+t} \hat{t} = 100\% - \frac{0.30}{1.30} 50\% = 88\%$$

With the tariff reduction, the substitution away from traded goods towards semitradable goods is less and the expansion in semitradables is smaller. On the other hand, since the inflation is lower, the real wage is lower in terms of the export price  $P_x^*$  and there is some expansion in commodity exports (not enough to compensate for the relative decrease in the growth rate of the production of semitradables so that total output is less with the tariff reduction).



The results above also show that if the nominal devaluation is judged to be "too small", it is probably (in spite of the inefficiencies which would persist in the

---

Thus, the curve for the devaluation accompanied by a tariff reduction almost looks like a curve for a 88 percent devaluation and is simply below the curve for a 100 percent devaluation. However, solving the model for the devaluation cum tariff reduction is not equivalent to systematically replacing the percentage change in the nominal exchange rate by the modified percentage change shown in the equation above. This is naturally due to the fact that an exchange rate change affects both import and export prices while a change in tariff only affects import prices.

economy) better to aim for a greater real depreciation by postponing the tariff reduction. An alternative way of stating this is that a large devaluation which may be perceived to be politically unsustainable could be replaced, in the short term, by a smaller nominal devaluation without a simultaneous reduction in tariffs.

#### 4.6. Introducing a Redistribution Effect

Until now, on the demand side, we only considered two types of consumers: the government and the private sector.

In order to analyse the potential effects of a redistribution of income following a devaluation, we now consider that there are two types of agents within the private sector. These are 1) the middlemen, who capture rents and profits in the production of the exported goods; and 2) the rest of the private sector. As long as middlemen and others have identical consumption pattern, nothing is gained by dividing the private sector in these two categories since contractionary or expansionary effects are related to income redistribution issues whenever the recipients have different propensity to save (and/or buy imported versus semitradable goods). Thus, in what follows, we assume that the consumption pattern of the middlemen differ from that of the rest of the private sector. It is assumed that middlemen consume only imports <sup>15/</sup> whereas the rest of the private sector consume as before both semitradables and imports. Thus, we now have three different types of consumers: 1) the government, 2) the middlemen, and 3) the rest of the private sector.

In what follows,  $M_g$  and  $M_h$  designate the quantities of imports consumed respectively by the middlemen and by the rest of the private sector.

We assume that the relative demand of semitradable and imports for the rest of the private sector is given by (equation (10) is unchanged but now only applies to the rest of the private sector):

$$\frac{C}{M_h} = \bar{K} \left[ \frac{P_M^* (1+t) e}{P_D} \right]^\alpha \quad (10')$$

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<sup>15/</sup> This extreme assumption, by introducing a sharp contrast in the consumption patterns, allows us to capture fully the redistribution effect. It corresponds to the existence of middlemen (who would capture the difference between farmgate and export price of an agricultural product) sending all their earnings abroad.

Profits in the production of the primary commodity  $X$  are given by:

$$\pi_X = (1-s) eP_X^* X - WL_X$$

Middlemen are assumed to consume only imports (taxed at the rate  $t$ ) and their budget constraint is given by:

$$(1-s) eP_X^* X - WL_X = eP_M^* (1+t) M_C \quad (11')$$

The income of the rest of the private sector now comes from the remuneration of labor in the export sector and from the value added in the semitradable good sector. The corresponding budget constraint is given by:

$$WL_X + P_V V = P_Q C + eP_M^* (1+t) M_h \quad (11'')$$

Total imports now include imports by middlemen and imports by the rest of the private sector. The external balance is therefore expressed as follows:

$$P_X^* X + \bar{F} = P_M^* (M_C + M_h + I + mG) + \mu i^* D^* \quad (12')$$

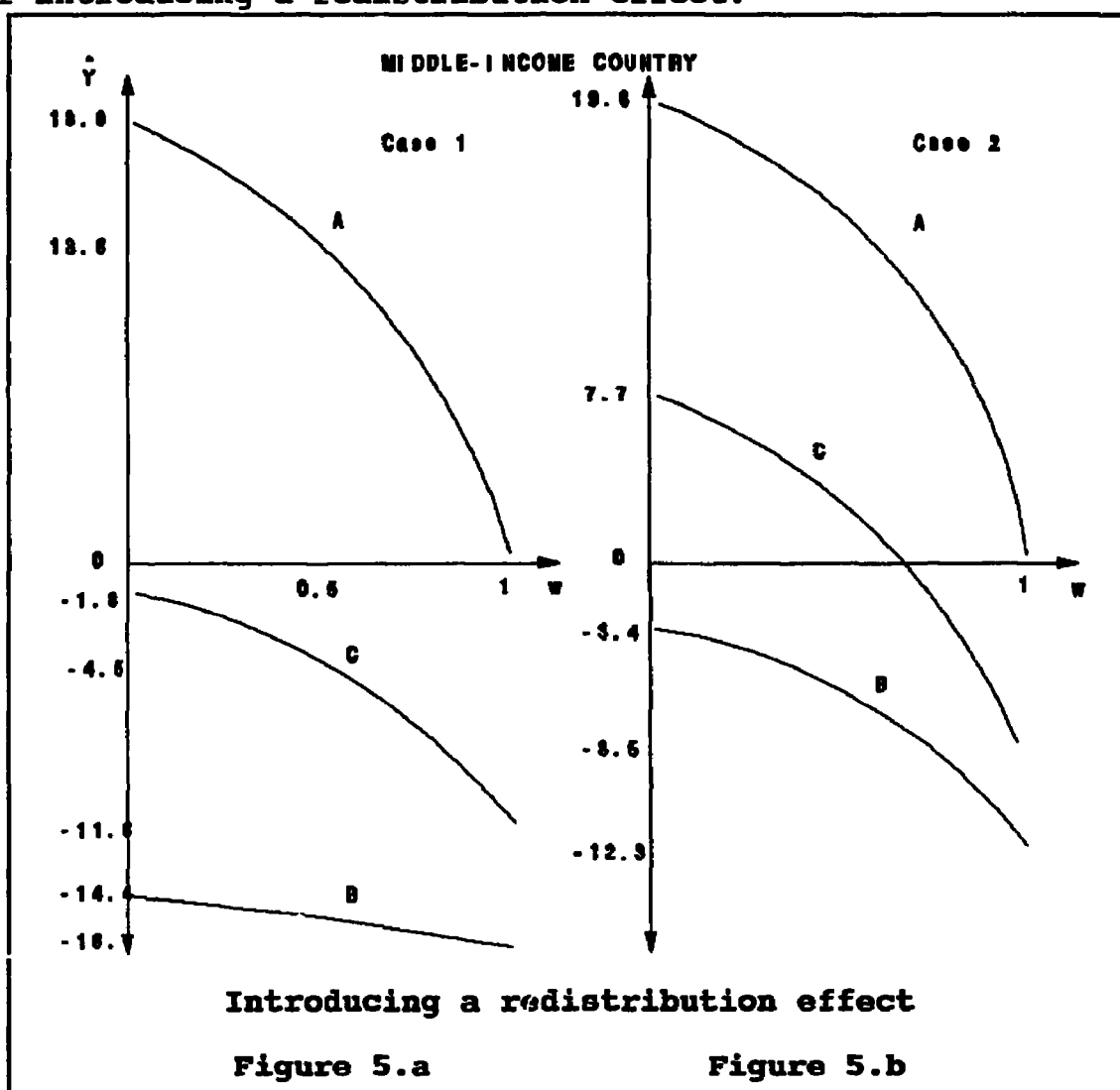
Compared to the log-linear form of the model used in the simulation described in the previous sections, we still have the same linear expressions, except for the percentage changes in  $C$  and in  $P_V$ . In addition, the linear version of the model with redistribution includes reduced-form equations for the percentage changes in  $M_C$  and  $M_h$ . The detailed calculations and the exact expressions for all the parameters are shown in the Appendix.

Besides the thirteen shares specified in the first version of the model (see Table 1), we need to know the values of two other shares to simulate this second version: 1) the share of imports by middlemen in foreign exchange expenditures ( $\gamma_{MC}$ ); and 2) the share of wages in export sector ( $\pi_w$ ). To simplify the presentation, we just show simulation results for the "middle-income" country. In order to illustrate the redistribution effect, we analyze two cases differentiated by the value of  $\gamma_{MC}$ : 1) imports by the middlemen equal to half of total imports so that  $\gamma_{MC}$  is equal to 0.25; and 2) imports by the middlemen equal to a third of total imports so that  $\gamma_{MC}$  is equal to 0.166. The value of  $\pi_w$  is assumed to be identical to the case without redistribution effects (set equal to the labor share ( $\gamma$ ) in the export sector of 0.6).



We also have to re-estimate the values of two of the thirteen shares considered in the first version as they only concern now the rest of the private sector (middlemen excluded). These two shares are the share of semitradables in private sector expenditures ( $\theta_c$ ) and the share of revenue from the export sector in total private sector revenue ( $\theta_x$ ). Their new values are re-calculated using the values estimated in the first version and the assumed values for  $\gamma_{Mc}$  and  $\pi_M$ . The values of the five specific shares for the two cases are summarized in Table 2.

Figures 5.a. and 5.b. show for the "middle-income" country the simulation results with a redistribution effect for the two cases described above. The comparison with the three curves shown in Figure 3.b (again curve A corresponds to the "right" timing, curve B to the "wrong" timing, and curve C to a "wrong" timing with debt relief) shows the consequences of introducing a redistribution effect.



With the redistribution effect, the fundamental difference comes from the fact that all additional rents and profits in the production of the export commodity associated with the devaluation are now only used for the purchase of imports. Therefore, the total demand for semitradables is now lower. As a consequence, the increase in  $P_0$  is smaller since the production of semitradables is now lower. The implied lower real wage in the exportable sector allows a relatively greater expansion in that sector. However, the relative gain in production of exportables is not enough to offset the relative loss in production of semitradables and, as a rule, the supply response to the devaluation is dampened.

Under a "right" timing, this dampening effect is very small (curve A is only slightly below the corresponding curve of Figures 3.b) and this regardless of the proportion of total imports consumed by the middlemen. In this case, the relative expansion in exportables which is facilitated both by the timing and the lower real wage is basically enough to offset the relative decrease in the production of semitradables. Therefore, although there are marked differences in the sectoral composition of output (with the greatest expansion in exportables and the smallest expansion in semitradables for case 1), the three cases (no redistribution effect, cases 1 and 2 of the redistribution effect) are almost identical as far as growth rate of total output is concerned.

However, things are quite different if the timing is "wrong". In the first case where middlemen consume half of total imports, the devaluation has been found to always be contractionary whether or not an attempt is made to offset the "wrong" timing with debt relief. Furthermore, the extent to which the devaluation is contractionary is not very sensitive to the degree of wage indexation (see curve B in Figure 5.a). For the second case, for which middlemen are assumed to consume a third of all imports, the devaluation remains contractionary as well. However, at least for low degrees of wage indexation, this can be corrected by debt relief in the sense that the devaluation can be expansionary.

With a "wrong" timing, all pass-through effects of the devaluation (price increase in local currency of the export commodity) leak into additional imports. The only source of demand for semitradables is the additional government consumption induced by the import taxes paid by the middlemen. The overall impact on the semitradables is negative. A greater degree of wage indexation favors the production of semitradables (though a demand effect) since it transfers income from the middlemen to the rest of the private sector and hurts the production of exportables by raising factor costs (supply effect).

This section has shown that, unless the timing is "right" in the sense that producers receive the ex-post price signal,

redistribution effects (in the sense that price increase of the primary export is passed on to middlemen who have a higher propensity to consume imported goods) can seriously jeopardize the success of a devaluation by preventing an expansion in the semitradables sector. In most cases, the devaluation was found to have potential contractionary effects which could not even be offset by debt relief.

## 5. Conclusions

This paper has evaluated under what circumstances, a devaluation could be contractionary in primary commodities exporter less developed countries. To do so, a model capturing the principal features of these economies, in particular those of the CFA countries, has been used to evaluate the impact of the devaluation. The two most important channels of transmission of the devaluation are: 1) a supply effect with the supply response for the tradables essentially a function of labor costs relative to the export commodity price; and 2) a demand effect with the supply response for the semitradables essentially a function of the real wage. The model was estimated for both a "middle-income" and a "low-income" country.

The simulation results confirm that a low degree of wage indexation is crucial to the success of a devaluation (this is the base case against which all other simulations are compared). Timing has been shown to matter and to do so comparatively even more in the "middle-income" country. Debt relief, which is a more powerful whenever the degree of wage indexation is lower, can help offset the negative effects of a "wrong" timing by increasing the growth rate of total output. It has been shown, however, that debt relief has an asymmetric effect on the exportable and the semitradable sectors. Furthermore, debt relief results in a worsening of the current account deficit which reinforces the need for additional debt relief or exogenous foreign capital inflows in the future.

With a tariff reduction, the devaluation is accompanied a somewhat greater expansion in tradables. However, this is not enough to compensate for the relative decrease in the growth rate of the production of semitradables so that total output is less. Thus, if the nominal devaluation is judged to be "too small", a possibility is to aim for a greater real depreciation by postponing the tariff reduction.

Finally, as has been shown in the previous section, unless the timing is "right", the presence of redistribution effects (with income being "transferred" from producers to middlemen with a higher propensity to consume imported goods) can have contractionary effects which cannot be offset by debt relief.

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Table 1. Parameter values

	"Middle-income" country	"Low-income" country
<u>Elasticities:</u>		
$\sigma$	0.20	0.10
$\Omega$	0.50	0.50
<u>Shares</u>		
$\theta$	0.10	0.05
$\gamma$	0.60	0.50
$m$	0.20	0.10
$\lambda_I$	0.20	0.10
$\lambda_G$	0.20	0.30
$\mu_I$	0.20	0.10
$\gamma_X$	0.75	0.60
$\gamma_N$	0.50	0.60
$\gamma_D$	0.20	0.10
$\gamma_I$	0.25	0.25
$\theta_c$	0.85	0.90
$\theta_x$	0.25	0.20
$v$	0.40	0.50
<u>Tax rates:16/</u>		
$t$	0.30	0.30
$s$	0.10	0.10

16/ The levels of import and export tax rates only matter if we introduce change in tax rates in the simulation.

**Table 2: Specific Shares for  
the model version with  
redistribution effects**

<b>"Middle-income" country</b>		
	<b>Case 1</b>	<b>Case 2</b>
$\gamma_{mh}$	0.25	0.334
$\gamma_{mc}$	0.25	0.166
$\pi_w$	0.6	0.6
$\theta'_c$	0.92	0.89
$\theta'_x$	0.17	0.17

## APPENDIX

## SOLUTION OF THE MODEL

## A.1 Equations of the Model

The equations of the model are repeated here for convenience. The equations of the first version (without a redistribution effect) are:

$$(1) \quad Q = k[\beta I^{-\rho} + (1-\beta) V^{-\rho}]^{-\frac{1}{\rho}}$$

$$(2) \quad V = \bar{A}_D L_D^{\gamma}$$

$$(3) \quad X = \bar{A}_X L_X^{\theta}$$

$$(4) \quad P_V V + P_M I = P_Q Q$$

$$(5) \quad \frac{I}{V} = k' \left( \frac{P_V}{P_M} \right)^{\sigma}$$

$$(6) \quad W = P_V \bar{A}_D^{\gamma} L_D^{\gamma-1}$$

$$(7) \quad W = (1-s) \psi e P_X^* \bar{A}_X^{\theta} L_X^{\theta-1}$$

$$(8) \quad \hat{W} = \omega \hat{P}_Q$$

$$(9) \quad Q = C + G(1-m)$$

$$(10) \quad \frac{C}{M} = \bar{K} \left[ \frac{P_M^* (1+t) e}{P_Q} \right]^a$$

$$(11) \quad (1-s) e P_X^* X + P_V V = P_Q C + e P_M^* (1+t) M$$

$$(12) \quad P_X^* X + \bar{F} = P_M^* (M+I+mG) + \mu i^* D^*$$

The first nine equations describing the second version of the model (version with a redistribution effect) are identical to that of the first version. The specific equations of the second version are as follows:

$$(10') \quad \frac{C}{M_h} = \bar{K} \left[ \frac{P_M^* (1+t) e}{P_Q} \right]^a$$

$$(10'') \quad (1-s) e P_X^* X - WL_X = e P_M^* (1+t) M_c$$

$$(11') \quad WL_X + P_V V = P_Q C + e P_M^* (1+t) M_h$$

$$(12') \quad P_X^* X + \bar{F} = P_M^* (M+I+mG) + \mu i^* D^*$$



## A.2. Solution of the Model in Linear Form

The strategy to solve the model is as follows: First, all equations in each version are log-differentiated, having replaced  $P_n$  by the expression shown after equation (4) in the main text. Second, substitutions of the linear equations are operated to express the percentage changes in the endogenous variables as a function of percentage changes in the exogenous variables and in  $P_v$ . Finally, using (12) in the first version and (12') in the second version, we can solve for the percentage change in  $P_v$  as a function of the percentage changes in exogenous variables only.

The linear equations for the twelve endogenous variables of the first version are as follows:

$$(A.1) \quad \hat{Q} = \frac{\gamma}{\gamma-1} [\hat{W} - \hat{P}_v] - \lambda_I \sigma [\hat{\varepsilon} + \frac{t}{1+t} \hat{c} - \hat{P}_v]$$

$$(A.2) \quad \hat{V} = \frac{\gamma}{\gamma-1} (\hat{W} - \hat{P}_v)$$

$$(A.3) \quad \hat{X} = \frac{\theta}{\theta-1} [\hat{W} + \frac{s}{1-s} \hat{s} - \Phi - \hat{\varepsilon}]$$

$$(A.4) \quad \hat{P}_Q = E_1 \hat{P}_v + E_2 (\hat{\varepsilon} + \frac{t}{1+t} \hat{c})$$

$$(A.5) \quad \hat{f} = \frac{\gamma}{\gamma-1} [\hat{W} - \hat{P}_v] - \sigma [\hat{\varepsilon} + \frac{t}{1+t} \hat{c} - \hat{P}_v]$$

$$(A.6) \quad \hat{L}_Q = \frac{1}{\gamma-1} (\hat{W} - \hat{P}_v)$$

$$(A.7) \quad \hat{L}_x = \frac{1}{\theta-1} [\hat{W} + \frac{s}{1-s} \hat{s} - \Phi - \hat{\varepsilon}]$$

$$(A.8) \quad \hat{W} = \omega E_1 \hat{P}_v + \omega E_2 (\hat{\varepsilon} + \frac{t}{1+t} \hat{t})$$

$$(A.9) \quad \hat{G} = \frac{1}{\lambda_G} [ - \lambda_C \hat{C} + (\frac{\gamma}{\gamma-1} (\omega E_1 - 1) + \lambda_I \sigma) \hat{P}_v \\ + (\frac{\gamma}{\gamma-1} \omega E_2 - \lambda_I \sigma) (\hat{\varepsilon} + \frac{t}{1+t} \hat{t}) ]$$

$$(A.10) \quad \hat{M} = \hat{C} + \Omega E_1 \hat{P}_v + \Omega (E_2 - 1) (\hat{\varepsilon} + \frac{t}{1+t} \hat{t})$$

$$(A.11) \quad \hat{P}_v = \frac{1}{e_1} [e_2 \hat{\varepsilon} + e_3 \frac{t}{1+t} \hat{t} + e_4 (\gamma_D \beta - \gamma_F \hat{P}) \\ + e_5 \frac{s}{1-s} \hat{s} + e_6 \Phi]$$

$$(A.12) \quad \hat{C} = \frac{1}{\alpha} [\beta_1 \hat{P}_v + \beta_2 (\hat{\varepsilon} + \frac{t}{1+t} \hat{t}) + \beta_3 (\gamma_F \hat{P} - \gamma_D \beta) \\ + \beta_4 (\frac{s}{1-s} \hat{s} - \Phi - \hat{\varepsilon})]$$

The first nine linear equations are similar in the first and in the second version of the model. The linear equations for the four other variables of the second version are:

$$(A.10') \quad \hat{M}_h = \hat{C} + \Omega E_1 \hat{P}_v + \Omega (E_2 - 1) (\hat{\varepsilon} + \frac{t}{1+t} \hat{t})$$

$$(A.10'') \quad \hat{M}_c = \frac{1}{1-\pi_N} \hat{\varepsilon} + \frac{\theta}{\theta-1} \omega E_1 \hat{P}_v + (\frac{\theta}{\theta-1} \omega E_2 - 1) (\hat{\varepsilon} + \frac{t}{1+t} \hat{t}) \\ + \frac{\theta-\pi_N}{(1-\pi_N)(\theta-1)} (\frac{s}{1-s} \hat{s} - \Phi - \hat{\varepsilon}) - \frac{1}{1-\pi_N} \frac{s}{1-s} \hat{s}$$

$$(A.11') \quad \hat{p}_v = \frac{1}{e_1} [e_2 \hat{e} + e_3 \frac{t}{1+t} \hat{c} + e_4 \frac{s}{1-s} \hat{s} - \Phi] \\ + \frac{\beta_3}{\alpha} (\gamma_F \hat{F} - \gamma_D \hat{\mu}) + \frac{\beta_6}{\alpha} \frac{s}{1-s} \hat{s}]$$

$$(A.12') \quad \hat{c} = \frac{1}{\alpha} [\beta_1 \hat{p}_v + \beta_2 (\hat{e} + \frac{t}{1+t} \hat{c}) + \beta_3 (\gamma_F \hat{F} - \gamma_D \hat{\mu}) \\ + \beta_4 (\frac{s}{1-s} \hat{s} - \Phi - \hat{e}) + \beta_5 \hat{e} + \beta_6 \frac{s}{1-s} \hat{s}]$$

In both versions, the growth rate of total output is a weighted average of the growth rates in output of semitradables and exportables:

$$\hat{Y} = v \hat{Q} + (1-v) \hat{X}$$

$v$  being the share of nominal value of semitradables in nominal value of total output.

### A.3. Definitions of the Shares and coefficients

#### A.3.1 Estimated shares in the first version

$$\lambda_I = \frac{\beta I^{-\rho}}{\beta I^{-\rho} + (1-\beta) V^{-\rho}} \quad ; \quad \lambda_V = 1 - \lambda_I$$

$$\lambda_G = \frac{(1-m) G}{Q} \quad ; \quad \lambda_C = 1 - \lambda_G$$

$$\mu_I = \frac{P_M I}{P_M I + P_V V} \quad ; \quad \mu_V = 1 - \mu_I$$

$$\gamma_X = \frac{P_X^* X}{P_X^* X + F} \quad ; \quad \gamma_F = 1 - \gamma_X$$

$$\gamma_M = \frac{P_M^* M}{P_M^* (M+I+mG) + \mu i^* D}$$

$$\gamma_D = \frac{\mu i^* D}{P_M^* (M+I+mG) + \mu i^* D}$$

$$\gamma_I = \frac{P_M^* I}{P_M^* (M+I+mG) + \mu i^* D} \quad ; \quad \gamma_G = 1 - \gamma_M - \gamma_I - \gamma_D$$

$$\theta_C = \frac{P_Q C}{P_Q C + eP_M^* (1+t)M} \quad ; \quad \theta_M = 1 - \theta_C$$

$$\theta_X = \frac{(1-s)eP_X^* X}{(1-s)eP_X^* X + P_V V} \quad ; \quad \theta_V = 1 - \theta_X$$

$$v = \frac{P_Q Q}{P_Q Q + eP_X^* X}$$

### A.3.2 Estimated shares in the second version

All the shares in the second version are the same as in the first version, except the following seven shares:

$$\gamma_{mh} = \frac{P_m^* M_h}{P_m^* (M_h + M_c + I + mG) + \mu i^* D} \quad ; \quad \gamma_{mc} = \gamma_m - \gamma_{mh}$$

$$\theta'_c = \frac{P_q C}{P_q C + e P_m^* (1+t) M_h} \quad ; \quad \theta'_n = 1 - \theta'_c$$

$$\theta'_x = \frac{W L_x}{P_v V + W L_x} \quad ; \quad \theta'_v = 1 - \theta'_x$$

$$\pi_N = \frac{W L_x}{(1-s) e P_x^* X}$$

### A.3.3 calculated coefficients in the first version

$$E_1 = \mu_v - (\lambda_I - \mu_I) \sigma$$

$$E_2 = \mu_I (1 - \sigma) + \lambda_I \sigma$$

$$\alpha = \gamma_M - \frac{\gamma_G \lambda_c}{\lambda_G}$$

$$\beta_1 = \frac{\theta}{\theta - 1} \gamma_x \omega E_1 - \frac{\gamma}{\gamma - 1} \left( \frac{\gamma_G}{\lambda_G} + \gamma_I \right) (\omega E_1 - 1) - \gamma_M \Omega E_1 - \gamma_I \sigma - \frac{\gamma_G \lambda_I \sigma}{\lambda_G}$$

$$\beta_2 = \left( \frac{\theta}{\theta - 1} \gamma_x - \gamma_I \frac{\gamma}{\gamma - 1} - \frac{\gamma_G}{\lambda_G} \frac{\gamma}{\gamma - 1} \right) \omega E_2 - \gamma_M \Omega (E_2 - 1) + \gamma_I \sigma + \frac{\gamma_G \lambda_I \sigma}{\lambda_G}$$

$$\beta_3 = 1 \quad ; \quad \beta_4 = \frac{\theta}{\theta-1} \gamma_x$$

$$\epsilon_1 = (\theta_x \frac{\theta}{\theta-1} \omega - \theta_c) E_1 - \frac{\beta_1}{\alpha} - \theta_M \Omega E_1 + \theta_v [1 + \frac{\gamma}{\gamma-1} (\omega E_1 - 1)]$$

$$\begin{aligned} \epsilon_2 &= \theta_c E_2 + \frac{1}{\alpha} (\beta_2 - \beta_4) + \theta_M [1 + \Omega (E_2 - 1)] \\ &+ \frac{\theta_x}{\theta-1} (1 - \theta \omega E_2) + \theta_v \frac{\gamma}{1-\gamma} \omega E_2 \end{aligned}$$

$$\epsilon_3 = \theta_c E_2 + \frac{\beta_2}{\alpha} + \theta_M [1 + \Omega (E_2 - 1)] + \theta_x \frac{\theta}{1-\theta} \omega E_2 + \theta_v \frac{\gamma}{1-\gamma} \omega E_2$$

$$\epsilon_4 = \frac{\beta_3}{\alpha} \quad ; \quad \epsilon_5 = \frac{\theta_x}{1-\theta} + \frac{\beta_4}{\alpha} \quad ; \quad \epsilon_6 = \theta_x \frac{\theta}{\theta-1} - \frac{\beta_4}{\alpha}$$

### A.3.3 calculated coefficients in the second version

In the second version, the following coefficients are the same as in the first version:

$$E_1, E_2, \text{ and } \beta_3$$

We also have the same expressions in both versions for  $\epsilon_1$ ,  $\epsilon_3$ , and  $\epsilon_4$ , except that  $\theta_c$ ,  $\theta_M$ ,  $\theta_x$ , and  $\theta_v$  in the first version are replaced by  $\theta'_c$ ,  $\theta'_M$ ,  $\theta'_x$ , and  $\theta'_v$  in the second version, respectively.

The specific coefficients for the second version are the following:

$$\alpha = \gamma_{Mb} - \frac{\gamma_G \lambda_G}{\lambda_G}$$

$$\begin{aligned} \beta_1 &= \frac{\theta}{\theta-1} \gamma_X \omega E_1 - \frac{\gamma}{\gamma-1} \left( \frac{\gamma_G}{\lambda_G} + \gamma_I \right) (\omega E_1 - 1) \\ &= \gamma_{Mb} \Omega E_1 - \gamma_I \sigma - \frac{\gamma_G \lambda_I \sigma}{\lambda_G} - \frac{\theta}{\theta-1} \gamma_{Mc} \omega E_1 \end{aligned}$$

$$\begin{aligned} \beta_2 &= \left( \frac{\theta}{\theta-1} \gamma_X - \gamma_I \frac{\gamma}{\gamma-1} - \frac{\gamma_G}{\lambda_G} \frac{\gamma}{\gamma-1} \right) \omega E_2 \\ &= \gamma_{Mb} \Omega (E_2 - 1) + \gamma_I \sigma + \frac{\gamma_G}{\lambda_G} \lambda_I \sigma - \gamma_{Mc} \left( \frac{\theta}{\theta-1} \omega E_2 - 1 \right) \end{aligned}$$

$$\beta_4 = \frac{\theta}{\theta-1} \gamma_X - \frac{\theta - \pi_N}{1 - \pi_N} \frac{\gamma_{Mc}}{\theta-1}$$

$$\beta_5 = - \frac{\gamma_{Mc}}{1 - \pi_N} ; \quad \beta_6 = \frac{1}{1 - \pi_N} \gamma_{Mc}$$

$$\begin{aligned} e_2 &= \theta'_C E_2 + \frac{1}{\alpha} (\beta_2 - \beta_4 + \beta_5) + \theta'_M [1 + \Omega (E_2 - 1)] \\ &+ \frac{\theta'_X}{\theta-1} (1 - \theta \omega E_2) + \theta'_V \frac{\gamma}{1-\gamma} \omega E_2 \end{aligned}$$

$$e_5 = \frac{\theta'_X}{1-\theta} + \frac{\beta_4}{\alpha} + \frac{\beta_6}{\alpha}$$

$$e_6 = \frac{\theta'_X}{\theta-1} - \frac{\beta_4}{\alpha}$$

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